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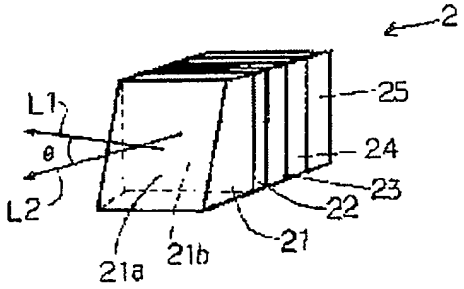
(54) POLARIZING ELEMENT AND SOLID-STATE PICKUP DEVICE USING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a polarizing element of high quality which can be produced at a low cost and can be made thin or small in size, and to provide a solid-state pickup device using that.
SOLUTION: This polarizing element is produced by laminating plural double refraction plates 21, 23, 25 (for example, by adhering), and at least one double refraction plate consists of lithium niobate. At least one principal plane of the lithium niobate double refraction plate makes an angle between ≥0° and <20 from the laminating direction of double refraction plates. By using this polarizing element for an optical low-pass filter in a solid state pickup device, it is suitable to make the device small in size.



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CLAIMS

[Claim(s)]
[Claim 1] The polarizing element characterized by the thing of the birefringent plate of this lithium niobate for which the principal plane, on the other hand, has 0-degree or more include angle of less than 20 degrees to the direction of a laminating of a birefringent plate at least while carrying out the laminating of the birefringent plate of two or more sheets, and changing and forming at least one sheet of these birefringent plates with lithium niobate.
[Claim 2] The solid state camera characterized by using a polarizing element according to claim 1 for the optical low pass filter of a solid state camera.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is suitable for the optical low pass filter which is used especially for optical signal processing of a solid state camera, and demonstrates effectiveness to image quality degradation about solid state cameras, such as a polarizing element which two or more sheets of a birefringent plate were made to coalesce, and was combined and a CCD camera, and a camcorder.
[0002]
[Description of the Prior Art] Conventionally, in the solid state camera of 3 chip methods, in order to perform color separation, the filter which constitutes the lattice called a stripe filter is used. However, when a stripe filter performed color separation, the light and darkness which are in agreement with a stripe filter pitch were in the photographic subject or the remarkable part of a light-and-darkness difference was in the scanning direction of a solid state camera, since the applicable component of the carrier frequency contained in the part went into the band-pass filter, has been recognized as a chrominance signal and became a false chrominance signal, the color of the photographic subject had independently the problem of degrading image quality.
[0003] Then, in order to raise resolution, it carries out [1 / / 2 ******], and law (it carries out [space ******] and called law) is used. This is a method which shifts a blue CCD chip and a red CCD chip, and arranges only one half of the sampling periods of a picture element to a green CCD chip. And although there is a phase grating filter, lenticular lens, and Xtal light filter etc. in the optical low pass filter for realizing this method, current and the Xtal light filter are in use.
[0004] As shown in drawing 3 , the optical low pass filter called such a Xtal light filter consists of the quartz plates 12-16 of two or more sheets, and uses those birefringences. That is, after the quartz plate 12 of thickness T of the 1st sheet separating the signal light 9 (ten in drawing shows the circular polarization of light) into the linearly polarized light light 11X and 11Y of a 2-way first and changing into two circular polarization of light light using the 1st quarter-wave length plate 13, the quartz plate 14 of thickness T / 2 of the 2nd sheet separates into the linearly polarized light light of four directions. Next, it changes into four circular polarization of light light using the 2nd quarter-wave length plate 15, the quartz plate 16 for perpendicular separation of the 3rd more sheet is passed, and, finally it separates into eight signal light.
[0005]
[Problem(s) to be Solved by the Invention] As mentioned above, according to the Xtal low pass filter which restricts the band of an image pick-up output signal, generating of a clinch strain could be prevented, but for Xtal used for the Xtal low pass filter, it was easy to generate crystal defects, such as a stria and inclusions, such a crystal defect became distortion of an image, and the cause of a sunspot, the problem was in quality or the yield, and the price was also expensive as a result. Moreover, the rate of a birefringence of Xtal is the wavelength of 632.8nm. About 0.009 It has the fault that it is small and a component is enlarged by this.
[0006] Therefore, this invention is thought out in view of such many problems, and it aims at offering the polarizing element in which the top which can manufacture cheaply, thin-shape-izing, and a miniaturization are possible with high quality, and the solid state camera using it.
[0007]

[Means for Solving the Problem] The polarizing element of this invention is characterized by for at least one sheet of said birefringent plate consisting of lithium niobate, and being in the range whose include angle theta of the normal vector of the principal plane of the birefringent plate of this lithium niobate and the normal vector of the rear face of this birefringent plate to accomplish is 0 degree <= theta< 20 degrees while it carries out the laminating of the birefringent plate of two or more sheets and changes (it sticking for example, and making it coalesce). That is, while carrying out the laminating of two or more birefringent plates, and changing and forming at least one sheet of these birefringent plates with lithium niobate, it is characterized by the thing of the birefringent plate of this lithium niobate for which the principal plane, on the other hand, has 0-degree or more include angle of less than 20 degrees to the direction of a laminating of a birefringent plate at least. Here, if an include angle theta becomes larger than 20 degrees, when outgoing radiation of the excessive reflected light will be carried out, it is necessary to make a special antireflection film put or and an include angle inclines greatly, a birefringent plate will become large and will cause enlargement.
[0008] A miniaturization becomes easy and is suitable if the above-mentioned polarizing element is especially used for the optical low pass filter of a solid state camera. In addition, a polarizing element consists of two or more birefringent plates and at least one quarter-wave length plate in this case, and at least one sheet of this birefringent plate consists of lithium niobate. Furthermore, it is good to use as lithium niobate the birefringent plate to which incidence of the light is carried out first, or both or either which carries out incidence to the last.
[0009]
[Embodiment of the Invention] First, the solid state camera S shown in drawing 1 is explained. as shown in drawing 3 , after it is alike with the optical low pass filter 2 and dissociating, the light lambda by which incidence was carried out to the lens 1 is decomposed into red, green, and a blue three-primary-colors light as it is also with prism 3. And light is received as the light decomposed by prism 3 is also for the CCD chips 4R, 4G, and 4B. The CCD driver 5 outputs the clock signal of a predetermined frequency to these CCD chip. He is trying for the CCD driver 5 to output a clock signal with the output signal of a timing generator 6 here.
[0010] The digital disposal circuits 7R, 7G, and 7B which process A/D conversion and a signal are connected to each CCD chip, respectively, and it is constituted so that the digital signal from these digital disposal circuits may be outputted to the image pick-up digital disposal circuit 8.
[0011] Here, the optical low pass filter 2 is LiNbO3 as shown in drawing 2 . It consists of birefringent plates 21, 23, and 25 of three sheets which consist of a single crystal, and two quarter-wave length plates 22 and 24 which consist of Xtal. In addition, this quarter-wave length plate may be a dielectric film.
[0012] At this invention, it is LiNbO3 in at least one among birefringent plates 21 (thickness T), 23 (thickness T/2), and 25 (thickness T). What is necessary is just to use a single crystal. And LiNbO3 Even if there are few birefringent plates of a single crystal, on the other hand, the principal plane should just have 0-degree or more include angle of less than 20 degrees to the direction of a laminating of a birefringent plate. That is, for example, the include angle (include angle of the normal vector L1 of 1 principal-plane 22a and the normal vector L2 of other labor attendant 22b to accomplish) theta which the normal vector (a direction is the same) of both the principal planes of a birefringent plate 22 accomplishes is in the range of 0 degree <= theta< 20 degrees. If the include angle which the normal vector of both the principal planes of all birefringent plates accomplishes suitably is in this numeric-value within the limits, it not only demonstrates a good polarization property, but thin-shape-izing and a miniaturization can be realized easily. That is, it not only becomes unnecessary for outgoing radiation of the excessive reflected light to be carried out by the optimal range of an include angle theta, and to make a special antireflection film put, but moreover, since theta is smaller than 20 degrees, it does not enlarge. here -- one sheet of a birefringent plate -- LiNbO3 ** -- either the birefringent plate 21 to which incidence of the light is first carried out when carrying out, or the birefringent plate 25 which carries out incidence to the last -- LiNbO3 ** -- contribution of a miniaturization is large by carrying out.
[0013] In addition, a birefringent plate and a quarter-wave length plate are SiO2. It is stuck that it is also with various adhesives, such as an antireflection film and epoxy systems, such as titanium oxide, and acrylic. In addition, about a fundamental operation of this optical low pass filter 2, since it is the

same as that of drawing 3 , explanation is omitted.
[0014] Moreover, this LiNbO3 For a single crystal, a birefringence is the wavelength of 632.8nm. 0.084 It is large, and in the optical-communication field, since establishment of the quality of an optical supply is made and the large-sized manufacture approach to the diameter of 5 inch is moreover established by direct raising from melt, it is convenient.
[0015] LiNbO3 A single crystal is manufactured by the following approaches. Fill up high-melting noble-metals crucibles, such as Pt, with the raw material for single crystal growth, and it is made to dissolve at a crystal training furnace above the melting point (1253 degrees C), and a melt front face is made to contact, rotating the seed crystal which descended to near the melting point and started melt skin temperature in the predetermined bearing next. Furthermore, a single crystal is obtained by growing up a crystal into the seed crystal pulled up while dropping the temperature of melt at the optimal rate.
[0016] And this single crystal is cooled and taken out to a room temperature, a bearing decision is made using an X-ray, and what carried out processing polish becomes usable as a birefringent plate of a low pass filter at a desired configuration.
[0017] It not only can offer a quality and cheap low pass filter by this, but since thin-shape-izing is possible, it can miniaturize the solid state camera itself.
[0018]
[Example] Next, a concrete example is explained.
[Example 1] LiNbO3 mixed by the harmony presentation ratio They are bore phi150mm and height of 100mm in 4,200g of raw materials of a single crystal. The crucible made from Pt is filled up. The seed crystal determined as the melt front face held to about 1,270 ** in the bearing perpendicular to the maximum side (43.9-degreerotY) of a birefringence by the X-ray after dissolving by about 1,300 ** is contacted, and it is 1 - 40rpm. The crystal was grown up by 0.5 - 5 mm/hr, making it rotate.
[0019] Thus, the raised crystal is phi80mmx100mm. It was very little good crystal of a defect. And a phi3 inch substrate is cut down from this crystal, and it is 0.1-2mm for optical low pass filters. Double-sided optical polish was given so that it might become thickness. At this example, it is LiNbO3. The birefringent plate is monotonous and the include angle which the normal vector of both that principal plane accomplishes is 0 degree.
[0020] Thus, produced LiNbO3 The optical low pass filter which is a polarizing element as performed nonreflective processing to three substrates of a single crystal and the quarter-wave length plate which consists of Xtal of two sheets and shown in lamination and drawing 2 was produced, and the engine performance was evaluated.
[0021] Consequently, compared with the optical low pass filter using Xtal as a birefringent plate, a property is more than an EQC altogether, and although the thickness acquires the same property, it ended with about 1 / seven to 1/6 (it has miniaturized to one ninth only with the birefringent plate). Furthermore, it is established and a high quality crystal manufacturing technology has the advantage in which crystal manufacture is possible by the very high yield.
[0022] In addition, it is LiNbO3 only, for example about one sheet of the birefringent plate of Xtal of three sheets. The same effectiveness as ** is seen also by changing to a single crystal.
[0023] [Example 2] LiNbO3 mixed by the harmony presentation ratio In 4,200g of single crystal raw materials, it is bore phi150mm. Height of 100mm The crucible made from Pt is filled up, the seed crystal by which a bearing decision was made with the X-ray at the X-axis is contacted on the melt front face held to 1,270 ** after dissolving by 1,300 **, and it is 1 - 40rpm. The single crystal was grown up by 0.5 - 5 mm/hr, making it rotate.
[0024] Thus, the raised single crystal is phi80mmx100mm. It was little crystal of a defect. It is 0.1-3mm about a phi3 inch substrate from this crystal. It started to thickness and optical polish was given to one side. Furthermore, it cut at intervals of 10mm in the direction which rotated 10 degrees - 45 degrees of crystallographic opticals axis, and polish processing of the split-face side which is another field was carried out at the wedge action die so that it might become the include angle of 5 **. LiNbO3 which serves as a birefringent plate in this example The include angle at which the normal vector of both that principal plane accomplishes a plate becomes 5 degrees.
[0025] This LiNbO3 Nonreflective processing was performed to three substrates and the quarter-wave length plate of Xtal, and the engine performance of lamination and a low pass filter was

evaluated. Consequently, compared with the low pass filter using Xtal, the property was more than an EQC, and only with the birefringent plate, although the same property is acquired, it could miniaturize to one ninth, and the thickness has been miniaturized in about 1 / seven to 1/6 as the whole.
[0026] Moreover, since it is a wedge-like, an include angle is given to incident light, and a birefringent plate can do the device of component arrangement. Furthermore, LiNbO3 Since it is established, crystal manufacture is possible for the high quality crystal manufacturing technology of a single crystal at the high yield.
[0027] In addition, the effectiveness with the same said of using LiNbO3 single crystal of a wedge action die is acquired, for example in at least one of three sheets.
[0028] Although the above-mentioned example explained taking the case of the optical low pass filter as a polarizing element, it is not limited to this and you may apply to polarizing elements, such as various prism.
[0029]
[Effect of the Invention] As explained above, according to the polarizing element of this invention, it can manufacture cheaply with high quality and, moreover, the thing in which thin-shape-izing and a miniaturization are possible can be offered.
[0030] Moreover, in the solid state camera using especially this polarizing element as an optical low pass filter, compared with the conventional Xtal low pass filter, a low pass filter small (thin shape) with high quality can be offered easily and cheaply, as a result a solid state camera still smaller than before can be offered.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The example of signal processing of a common solid state camera
[Drawing 2] The common block diagram of an optical low pass filter
[Drawing 3] The common block diagram of an optical low pass filter
[Description of Notations]
1 ... Lens
2 ... Optical Low Pass Filter
3 ... Prism
4R, 4G, 4B ... CCD chip
5 ... CCD Driver
6 ... Timing Generator
7R, 7G, 7B ... Digital disposal circuit
8 ... Image Pick-up Digital Disposal Circuit
S ... Solid state camera
21, 23, 25 ... Birefringent plate
22 24 ... 1/4 polarizing plate

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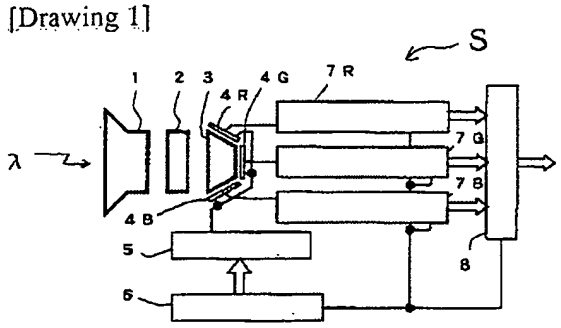
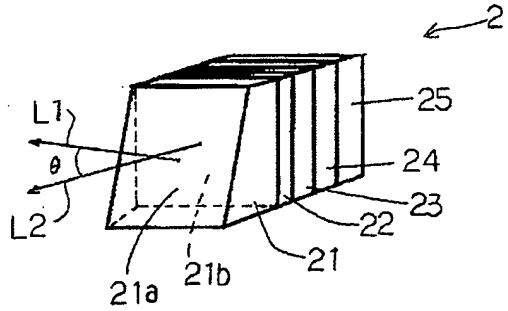
DRAWINGS

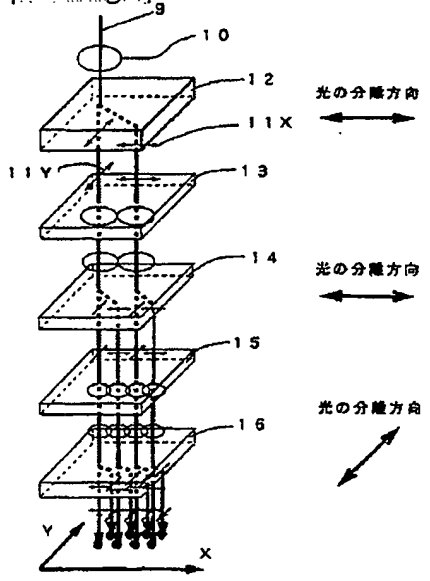
[Drawing 1]



[Drawing 2]



[Drawing 3]



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TITLE: POLARIZING ELEMENT AND SOLID-STATE PICKUP DEVICE USING THE SAME

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INVENTOR-INFORMATION:
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ABSTRACT:

PROBLEM TO BE SOLVED: To provide a polarizing element of high quality which can be produced at a low cost and can be made thin or small in size, and to provide a solid-state pickup device using that.

SOLUTION: This polarizing element is produced by laminating plural double refraction plates 21, 23, 25 (for example, by adhering), and at least one double refraction plate consists of lithium niobate. At least one principal plane of the lithium niobate double refraction plate makes an angle θ between $0° \leqq \theta < 20°$ from the laminating direction of the double refraction plates.
By using this polarizing element for an optical low-pass filter in a solid state pickup device, it is suitable to make the device small in size.

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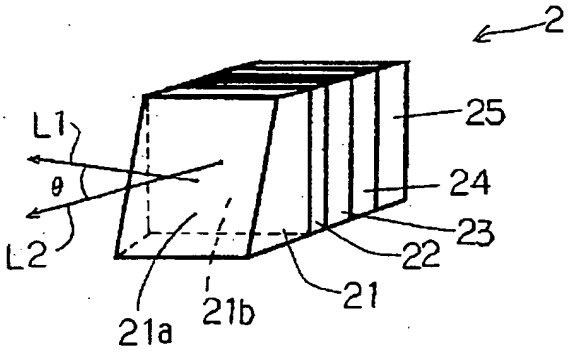
(54)【発明の名称】　偏光素子及びそれを用いた固体撮像装置

(57)【要約】

【課題】　高品質でかつ安価に製造が可能である上、薄型化や小型化が可能な偏光素子、及びそれを用いた固体撮像装置を提供すること。

【解決手段】　偏光素子は、複数枚の複屈折板２１，２３，２５を積層させて（例えば、貼り合わせて）成るとともに、複屈折板の少なくとも１枚がニオブ酸リチウムから成り、ニオブ酸リチウムの複屈折板の少なくとも一方主面が複屈折板の積層方向に対して０°以上２０°未満の角度を有していることを特徴とする。また、このような偏光素子を固体撮像装置の光学的ローパスフィルタに用いると小型化が容易となり好適である。



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【特許請求の範囲】

【請求項１】　複数枚の複屈折板を積層させて成り、且つこれら複屈折板の少なくとも１枚がニオブ酸リチウムで形成されているとともに、該ニオブ酸リチウムの複屈折板の少なくとも一方主面が複屈折板の積層方向に対して０°以上２０°未満の角度を有していることを特徴とする偏光素子。

【請求項２】　請求項１に記載の偏光素子を固体撮像装置の光学的ローパスフィルタに用いたことを特徴とする固体撮像装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、複屈折板の複数枚を合体させ組み合わせた偏光素子、及びＣＣＤカメラやビデオ一体型カメラなどの固体撮像装置に関するものであって、特に固体撮像装置の光信号処理に使用され、画質劣化に効果を発揮する光学的ローパスフィルタに好適なものである。

【０００２】

【従来の技術】従来より、３チップ方式の固体撮像装置では色分離を行うために、ストライプフィルタと呼ばれる格子状構造を成すフィルタが用いられている。ところが、ストライプフィルタにより色分離を行う場合に、被写体にストライプフィルタピッチと一致する明暗があったり、固体撮像装置の走査方向に明暗差の著しい部分があると、その被写体の色とは無関係に、その部分に含まれる搬送周波数の該当成分は、その帯域通過フィルタに入り、色信号として認識され疑似色信号となるので、画質を劣化させてしまうといった問題があった。

【０００３】そこで、解像度を向上させるために、１／２絵素ずらし法（空間絵素ずらし法とも呼ばれる）が用いられている。これは、緑のＣＣＤチップに対して、絵素のサンプリング周期の１／２だけを、青のＣＣＤチップ及び赤のＣＣＤチップをずらして配置する方式である。そして、この方式を実現するための光学的ローパスフィルタには、位相格子フィルタ，レンチキュラーレンズ，水晶光学フィルタなどがあるが、現在、水晶光学フィルタが主流になっている。

【０００４】このような水晶光学フィルタと呼ばれる光学的ローパスフィルタは、図３に示すように、複数枚の水晶板１２～１６から成り、それらの複屈折を利用するものである。すなわち、まず１枚目の厚みＴの水晶板１２で信号光９（図中１０は円偏光を示す）を２方向の直線偏光光１１Ｘ，１１Ｙに分離し、１枚目の１／４波長板１３を用いて２個の円偏光光に変換した後、２枚目の厚みＴ／２の水晶板１４で４方向の直線偏光光に分離する。次に２枚目の１／４波長板１５を用いて４個の円偏光光に変換して、さらに３枚目の垂直分離用の水晶板１６を通過させ、最終的に８個の信号光に分離するものである。

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【０００５】

【発明が解決しようとする課題】上述したように、撮像出力信号の帯域を制限する水晶ローパスフィルタによれば、折り返しひずみの発生を防止できるが、水晶ローパスフィルタに用いられる水晶には、脈理やインクルージョンなどの結晶欠陥が発生し易く、このような結晶欠陥が画像の歪や黒点の原因になり、品質や歩留まりに問題があり、結果的に価格も高価となっていた。また、水晶の複屈折率は波長632.8nm で約0.009 と小さく、これにより素子が大型化するといった欠点を有する。

【０００６】従って、本発明はこのような諸問題に鑑み案出されたものであって、高品質でかつ安価に製造が可能である上、薄型化や小型化が可能な偏光素子、及びそれを用いた固体撮像装置を提供することを目的とする。

【０００７】

【課題を解決するための手段】本発明の偏光素子は、複数枚の複屈折板を積層させて（例えば、貼り合わせて合体させて）成るとともに、前記複屈折板の少なくとも１枚がニオブ酸リチウムから成り、かつ該ニオブ酸リチウムの複屈折板の主面の法線ベクトルと該複屈折板の裏面の法線ベクトルとの成す角度θが０°≦θ＜２０°の範囲にあることを特徴とする。すなわち、複数の複屈折板を積層させて成り、且つこれら複屈折板の少なくとも１枚がニオブ酸リチウムで形成されているとともに、該ニオブ酸リチウムの複屈折板の少なくとも一方主面が複屈折板の積層方向に対して０°以上２０°未満の角度を有していることを特徴とする。ここで、角度θが２０°より大きくなると、余分な反射光が出射されることになり特殊な反射防止膜を被着させる必要があったり、角度が大きく傾くことにより複屈折板が大きくなり大型化を招く。

【０００８】特に、上記偏光素子を固体撮像装置の光学的ローパスフィルタに用いると小型化が容易となり好適である。なおこの場合、複数の複屈折板と少なくとも１枚の１／４波長板とで偏光素子が構成され、この複屈折板の少なくとも１枚がニオブ酸リチウムで構成される。さらに、光を最初に入射させる複屈折板と最後に入射させる複屈折板の両方もしくはいずれか一方をニオブ酸リチウムとするとよい。

【０００９】

【発明の実施の形態】まず、図１に示す固体撮像装置Ｓについて説明する。レンズ１に入射された光λは、図３に示すごとく光学的ローパスフィルタ２によりに分離された後、プリズム３でもって赤，緑，青の３原色光に分解される。そして、プリズム３により分解された光は、ＣＣＤチップ４Ｒ，４Ｇ，４Ｂでもって受光される。これらＣＣＤチップには、ＣＣＤドライバ５が所定の周波数のクロック信号を出力する。ここで、ＣＣＤドライバ５はタイミングジェネレータ６の出力信号によりクロック信号を出力するようにしている。

【００１０】各ＣＣＤチップには、Ａ／Ｄ変換や信号を処理を行う信号処理回路７Ｒ，７Ｇ，７Ｂがそれぞれ接続されており、これら信号処理回路からのディジタル信号が撮像信号処理回路８に出力されるように構成されている。

【００１１】ここで、光学的ローパスフィルタ２は、図２に示すように$LiNbO_3$ 単結晶から成る３枚の複屈折板２１，２３，２５と、例えば水晶から成る２枚の１／４波長板２２，２４とから構成されている。なお、この１／４波長板は誘電体膜であってもよい。

【００１２】本発明では、複屈折板２１（厚さＴ），２３（厚さＴ／２），２５（厚さＴ）のうち、少なくとも１枚に$LiNbO_3$ 単結晶を用いればよいのである。そして、$LiNbO_3$ 単結晶の複屈折板の少なくとも一方主面が複屈折板の積層方向に対して０°以上２０°未満の角度を有していればよい。すなわち、例えば、複屈折板２２の両主面の法線ベクトル（方向が同一）の成す角度（一主面２２ａの法線ベクトルＬ１と他出面２２ｂの法線ベクトルＬ２との成す角度）θが、$0° \leqq \theta < 20°$ の範囲にある。好適には全ての複屈折板の両主面の法線ベクトルの成す角度がこの数値範囲内にあれば、良好な偏光特性を発揮するだけでなく、薄型化や小型化が容易に実現できる。すなわち、角度θの最適範囲により余分な反射光が出射され特殊な反射防止膜を被着させることが不要になるだけでなく、しかもθが２０°より小さいので大型化することもない。ここで、複屈折板の１枚だけを$LiNbO_3$ とする場合は、光を最初に入射させる複屈折板２１、もしくは最後に入射させる複屈折板２５のいずれか一方を$LiNbO_3$ とすることにより小型化の寄与が大きい。

【００１３】なお、複屈折板と１／４波長板とはSiO_2 や酸化チタン等の反射防止膜及びエポキシ系やアクリル系などの各種接着剤でもって貼り合わせられている。なお、この光学的ローパスフィルタ２の基本的な作用については、図３と同様であるので説明を省略する。

【００１４】また、この$LiNbO_3$ 単結晶は複屈折が波長632.8nm で0.084 と大きく、光通信分野では光学用品質の確立がなされ、しかも融液からの直接引き上げにより５インチ径までの大型製造方法が確立されているので好都合である。

【００１５】$LiNbO_3$ 単結晶は次のような方法で製造される。Ｐｔなどの高融点貴金属坩堝に単結晶育成用原料を充填し結晶育成炉にて融点（１２５３℃）以上で融解させ、次に融液表面温度を融点近傍まで降下し、所定方位に切り出した種結晶を回転させながら融液表面に接触させる。さらに、融液の温度を最適な速度で降下させながら引き上げた種結晶に、結晶を成長させることにより単結晶が得られる。

【００１６】そして、この単結晶を室温まで冷却して取り出し、Ｘ線を用いて方位決定し、所望の形状に加工研磨したものがローパスフィルタの複屈折板として使用可能となる。

【００１７】これにより、高品質で安価なローパスフィルタを提供できるだけでなく、薄型化が可能であるので固体撮像装置自体を小型化できる。

【００１８】

【実施例】次に、具体的な実施例について説明する。

〔実施例１〕調和組成比に混合された$LiNbO_3$ 単結晶の原料4,200gを内径φ150mm，高さ100mm のＰｔ製坩堝に充填し、約1,300 ℃で融解した後、約1,270 ℃に保持した融液表面に、Ｘ線により複屈折の最大面（43.9° rotY）に垂直な方位に決定された種結晶を接触させ、１～40rpm にて回転させながら0.5 ～5mm/hrで結晶を成長させた。

【００１９】このように育成された結晶は、φ80mm×100mm の欠陥の非常に少ない良好な結晶であった。そして、この結晶からφ3インチの基板を切り出し、光学的ローパスフィルタ用に0.1 ～2mm 厚になるように両面光学研磨を施した。この実施例では$LiNbO_3$ の複屈折板は平板であり、その両主面の法線ベクトルの成す角度は０°である。

【００２０】このようにして作製した$LiNbO_3$ 単結晶の基板３枚と２枚の水晶から成る１／４波長板に無反射処理を施して貼り合わせ、図２に示すような偏光素子である光学的ローパスフィルタを作製し、その性能を評価した。

【００２１】その結果、複屈折板として全て水晶を用いた光学的ローパスフィルタと比べ特性は同等以上であり、その厚みは同一特性を得るのに１／７～１／６程度で済んだ（複屈折板だけでは１／９に小型化できた）。さらに、高品質結晶製造技術は確立されており、非常に高い歩留まりで結晶製造が可能である利点がある。

【００２２】なお、たとえば３枚の水晶の複屈折板の１枚だけを$LiNbO_3$ 単結晶に替えることでもは同様な効果は見られる。

【００２３】〔実施例２〕調和組成比に混合された$LiNbO_3$ 単結晶原料4,200gを、内径φ150mm 高さ100mm のＰｔ製坩堝に充填し、1,300 ℃で融解した後1,270 ℃に保持した融液表面に、Ｘ線によりＸ軸に方位決定された種結晶を接触させ、１～40rpm にて回転させながら0.5 ～5mm/hrで単結晶を成長させた。

【００２４】このように育成された単結晶はφ80mm×100mm の欠陥の少ない結晶であった。本結晶からφ3インチの基板を0.1 ～3mm 厚に切り出し、片面に光学研磨を施した。さらに、結晶学的光軸を10°～45° 回転させた方向に10mm間隔で切断し、もう一方の面である粗面側を5°の角度になるよう楔型に研磨加工した。この実施例では複屈折板となる$LiNbO_3$ 板はその両主面の法線ベクトルの成す角度は5°となる。

【００２５】この$LiNbO_3$ 基板３枚と水晶の１／４

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波長板に無反射処理を施して張り合わせ、ローパスフィルタの性能を評価した。その結果、水晶を用いたローパスフィルタと比べ特性は同等以上であり、同一特性を得るのにその厚みは複屈折板だけでは1／9に小型化でき、全体としては1／7～1／6程度に小型化できた。

【００２６】また、複屈折板は楔形状であるので入射光に対し角度がつけられ、素子配置の工夫が出来る。さらに、$LiNbO_3$ 単結晶の高品質結晶製造技術は確立されているので、高い歩留まりで結晶製造が可能である。

【００２７】なお、たとえば3枚のうちの少なくとも1枚を楔型のＬｉＮｂＯ３単結晶を用いることでも同様な効果は得られる。

【００２８】上述の実施例では偏光素子として光学的ローパスフィルタを例にとり説明したが、これに限定されるものではなく、例えば各種プリズム等の偏光素子に適用してもよい。

【００２９】

【発明の効果】以上説明したように、本発明の偏光素子によれば、高品質でかつ安価に製造が可能で、しかも薄型化，小型化が可能なものを提供できる。

【００３０】また、特にこの偏光素子を光学的ローパス

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フィルタとして用いた固体撮像装置においては、従来の水晶ローパスフィルタに比べ高品質で且つ小型（薄型）なローパスフィルタを容易かつ安価に提供することができ、ひいては、従来よりいっそう小型の固体撮像装置を提供できる。

【図面の簡単な説明】

【図１】一般的な固体撮像装置の信号処理例

【図２】光学的ローパスフィルタの一般的な構成図

【図３】光学的ローパスフィルタの一般的な構成図

【符号の説明】

１　・・・　レンズ

２　・・・　光学的ローパスフィルタ

３　・・・　プリズム

４Ｒ，４Ｇ，４Ｂ　・・・　ＣＣＤチップ

５　・・・　ＣＣＤドライバ

６　・・・タイミングジェネレーター

７Ｒ，７Ｇ，７Ｂ　・・・　信号処理回路

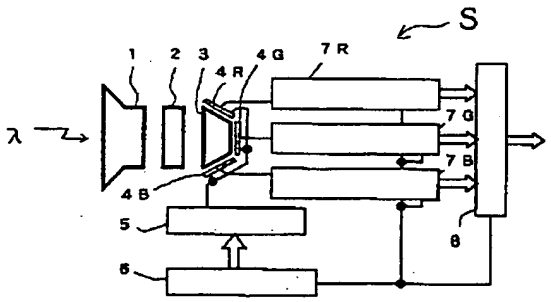
８　・・・　撮像信号処理回路

Ｓ　・・・　固体撮像装置

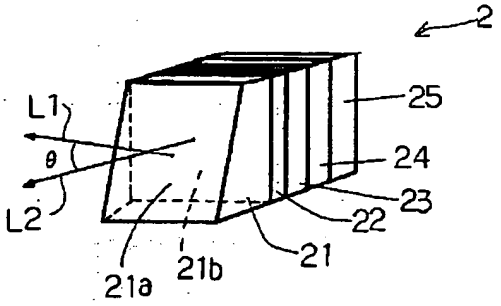
２１，２３，２５　・・・　複屈折板

２２，２４　・・・　１／４偏光板

【図１】



【図２】



【図3】